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JOINT INVENTORS
30151/38183

APPLICATION FOR UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that we, Bernd Lohmüller, a citizen of Germany, residing at Fuchsgraben 37, 91126 Schwabach, Germany, and Rainer Vockentanz, a citizen of Germany, residing at Walpersdorfer Strasse 26a, 91126 Schwabach, Germany, a citizen of Germany have invented a new and useful ANNEALING APPARATUS, of which the following is a specification.

11 pats

Annealing apparatus

Field of the Invention

The present invention relates to an annealing apparatus for the annealing of metallic billets and especially for the annealing of billets containing aluminum, as well as a procedure of manufacturing metallic, low-stressed billets, particularly metallic low-stressed billets which contain aluminum.

Background of the Invention

A billet in the sense of the present invention is in particular a metallic wire which has an integrally-formed cross-sectional area perpendicular to its longitudinal axis or a bundle of such metallic wires.

Subsequent to the cold processing of a metallic billet, and especially after a metallic billet has been drawn, structural changes can be observed in said metallic billet, which is also especially the case with billets made of aluminum or aluminum alloys. These structural changes in particular have an effect of hardening the billet and reducing its elongation at rupture. Such structural changes limit the uses for a billet so that a feasible measure to remedy same consists in stress-relief annealing of the billet, which induces a re-crystallization of its structure. In so doing, the billet is heated employing direct resistance heating for engineering and economic reasons. This direct resistance heating integrates a section of the billet, respectively one billet segment at a time, into an electrical circuit so that an electric current flows through said billet section or segment and, due to the electrical resistance of the billet, at least a portion of the electrical energy is converted to thermal energy, hence heating the billet.

During resistance heating, respectively annealing, the billet is guided, for example continuously, along a plurality of contact plates. Said contact plates are connected to a voltage source such that a current can flow through the metallic billet.

Considerable problems arise when current is transmitted from contact plates to billets containing aluminum or aluminum alloys. Such problems give rise to having to operate

these types of devices in a cost-intensive manner and result in the quality of the annealed billet not remaining constant over time.
The inventor is additionally aware that billets made of aluminum or of an aluminum alloy are heated in furnaces (furnace or drop annealing) in batch processing. Thus, the billets supported on a metallic spool or other metallic carrier are subjected to a protective gas atmosphere in an annealing furnace for a period of several hours.

Such a process necessitates great technical production expenditures as well as being energy and cost-intensive and furthermore gives rise to extremely long passage times with high process costs and frequently inadequate product quality.

The inventor is moreover aware that in the production of rods, wire is annealed employing a consumptionsly annealing passage process based on a conductive principle, although the quality of such products is generally insufficient in this case as well.

A. 3rd Summary of the Invention

It is thus the task of the present invention to provide an annealing apparatus for the treatment of a metallic billet, and particularly for the annealing of a billet which contains aluminum, as well as a method of manufacturing a metallic, low-stressed billet, and most notably a low-stressed billet which contains aluminum, in which electrical current can be transmitted to the billet in an economical and structurally simple manner of engineering over short passage times, so that as a result of said current flow, at least a section thereof will be heated, whereby the contact elements transferring the electrical current to the billet will enjoy a long operating life.

Sub A'

A special aspect of the task of the invention is to provide a apparatus which allows for the simplified and improved technical engineering of cold processing and subsequent annealing of a metallic billet, and in particular a billet made of or containing aluminum.

This task is solved by an annealing apparatus in accordance with claim 1.

An inventive process is the object of claims 16 and 18.

Preferred embodiments of the invention comprise the subject matter of the subclaims. The present invention proposes an annealing apparatus for annealing a metallic billet which has at least two contact elements made of electrically conducting material which are electrically connected to a voltage source and induce an electrical current to flow through at least one respective segment of the billet when said billet is guided past to come into contact with said contact elements. Said contact elements are made of a metal or a metal alloy which matches that of the billet's material to such an extent that basically no material from the billet diffuses into said contact elements. Said contact elements are configured as contact plates.

The billet is preferably of a light metal or a light metal alloy. A billet made from aluminum or aluminum alloy is especially preferred. The contact element material is preferably that of the same light metal as is contained in the billet material. It is especially preferred when the contact element material is an alloy of said light metal.

The voltage source may be a three-phase or a direct current source.

The annealing apparatus according to the present invention enables the producing of annealed billet material made of aluminum or aluminum alloy or the like in a technically simple as well as energy and cost-efficient manner, and most notably particularly with a high product quality and low waste factor. Furthermore, the present invention allows for reduced passage times at lower process costs during the manufacture of an annealed billet made of aluminum or aluminum alloy or the like.

Thus, the present invention can, for example, reduce the number of process steps by eliminating the need for a furnace when annealing. Related procedural expenditures are likewise eliminated such as an additional spool transport or needing to respool from the wire spools used in the furnace to synthetic spools used for transport. Since the present invention eliminates the need for lengthy warm-up and continuous heating phases of a wire drum in a furnace, it enables an increase in productivity and a shortening of the passage times. Additionally, an annealing apparatus in accordance with the present invention can be employed very flexibly, having a positive and process-simplifying effect when, for example, annealing different sized drums or differing wire materials.

The quality of an annealed billet produced with the inventive annealing apparatus is improved compared to annealed billets produced especially in furnaces. Waste is likewise reduced. This can be attributed to the present invention precluding such contingencies such as, for example, the wire material sticking to a spool or a wire drum during or after furnace annealing treatment and/or frequently continuing an undesired re-crystallization during the cooling-down phase.

The invention also has advantages from an energy-saving point of view since it avoids any additional expenditure of wasted energy as arises in furnace annealing with respect to, for example, the unnecessary heating of spools or wire drum carriers.

Moreover, the contact elements of the present invention do not exhibit any significant wear. Additionally, the wire surface suffers no damage at the contact points in accordance with the present invention.

Especially preferred is the detachable arrangement of the contact elements, contact plates respectively, on the annealing apparatus so that they may be replaced by others if another type of billet material is to be heated, respectively annealed in said annealing apparatus.

The electrical current is preferably transmitted from the voltage source to the contact elements by means of brushes or the like. The billet material is preferably moved through said annealing apparatus along a predefined transport track through said annealing apparatus, whereby especially a guiding means such as deviating or comb rollers or the like are hereto provided. Especially preferred are guiding means which do not function as contact elements under certain set circumstances so that the billet being transported along the transport track is not subjected to an electrical current flow at predetermined sections within the annealing apparatus.

It is preferred to have a plurality of annealing paths arranged along the transport track whereby one annealing path is disposed at an area of the transport track where the billet, or a portion of the billet, or the segment of the billet presently at this point

receives a flow of electrical current as transmitted to the billet by means of the contact elements.

According to a preferred embodiment of the present invention, various different annealing paths of differing lengths and/or which allow for the feeding of varying electrical current energy to the billet are disposed along the transport track.

The invention is in this respect advantageous as it enables significantly prolonging the operating life of the contact plates, contact elements respectively. Hence the invention particularly enables annealing of an aluminum billet by means of conductive heating, respectively direct resistance heating in an economical manner whereby the contact elements are not quickly destroyed, for example just after 15 or 30 minutes.

The invention consequently avoids the situation of aluminum from the billet diffusing into the contact elements which induces intermetallic phases to form in the contact elements and cause material embrittlement. Such material embrittlement causes track grooves to form on the contact elements which in turn can lead to the billet material slipping on the contact elements such that frictional wear results and leads to further destruction of the contact elements or to damaging of the billet.

According to a preferred embodiment of the present invention, the contact elements which are positioned at the same annealing path, meaning in particular the contact element which functions as a positive pole and the contact element which functions as its associated negative pole, are made of the same material.

The present annealing apparatus is preferably disposed with a cold-processing means for processing the billet in cold state whereby it is preferable to draw the billet into said means. Particularly preferred is the physical positioning of said cold-processing means in front of an annealing path in the material flow direction. It is preferred to have a plurality of cold-processing means whereby one or more annealing paths are positioned after at least one of said cold-processing means in the material flow direction.

A preferred annealing apparatus in accordance with the present invention is provided with a cooling section as a part of the transport track in which the billet may be cooled. A cooling means or medium is provided for cooling the billet. A billet may be cooled by using oil within the cooling section, with a thin oil being hereby especially preferred.

Sub A6

The billet is preferably moved through said thin oil following the annealing process.

The use of oil as a coolant is in this respect advantageous since oil prevents the formation of oxidation build-up on the surface of a billet or the surface of a billet containing aluminum.

Contingent upon the subsequent use of the billet, when using oil as a coolant, it is preferred to use oil which will essentially have no damaging effects on health.

The use of such an oil is in this respect advantageous because the billet will then be safe to use for clips or staples or other such similar articles which may come into contact with food.

The present annealing apparatus is preferably disposed with a stripping or similar means for removing any coolant or other residue from the surface of the billet. The stripping means is preferably physically positioned after the cooling section in the material flow direction. The stripping means is preferably configured as a die.

The stripping means, which is particularly preferably configured as a die, is preferably cooled and/or lubricated with the same cooling oil as used in the cooling means.

According to an especially preferred embodiment of the present invention, the billet is moved through a protective gas atmosphere at predetermined sections of the transport track with pure nitrogen in particular being hereto employed as a protective gas.

Sub A7

It is preferred that the billet is moved in the transport direction from a cold-processing means through at least one annealing path and subsequently through a cooling

Sub A6 cont

section, whereby said cold-processing means is disposed with one or more dies of which a terminal die constitutes the last die in the transport direction. In thus doing, a protective gas atmosphere is provided between said terminal die and said preferably oil-employing cooling section.

The protective gas atmosphere prevents the formation of oxidation build-up on billets and most particularly on billets which contain aluminum.

Sub A7

It is preferred for the annealing apparatus to be disposed with a drawing means, particularly configured as a draw plate, and which can subject the billet to a force which induces same to be moved along the transport track at a consistently uniform tension. Such drawing means, draw plate respectively, is preferably disposed with a separate motor, or a motor which is allocated solely to said drawing means, for driving said drawing means, draw plate respectively.

This allows for catching any possible increases in billet speed due to thermal expansion or diameter shrinkage.

Sub A8

It is especially preferred to have a regulating device control the rotational speeds of the different contact plates such that billet slippage is prevented, and notably also including when the billet expands subject to annealing path temperature. Certain predefined parameters can in particular be employed for said regulating control such as annealing temperature, or a parameter representative of the billet material, the length of the annealing path, the diameter of the billet, etc.

Sub A9

In a procedure in accordance with the present invention, the contact elements employed in the annealing apparatus preferably contain aluminum when a billet containing aluminum is to be annealed in said annealing apparatus. Said contact elements are connected to a voltage source such that a billet containing aluminum which comes into physical contact with said contact elements as it is passed by, receives an electrical current flow through its respective sections between said contact elements which induces a heating of the billet such that it is annealed at low stress.

Following annealing, the billet, and most particularly a billet containing aluminum, is preferably cooled by means of an oil, and in particular a thin oil.

The oil fed to cool the billet is preferably stripped off following the cooling process, and most particularly by the employing of a die.

The present invention encompasses a number of additional exemplary embodiments, the description of individual embodiments is not to be considered as waived.

Brief Description of the Drawings

In the following, the invention will be described in greater detail with reference to the drawing, which is not to be considered as restricting of the present invention, and which shows:

Fig. 1 shows a schematic partial cut-away view of an exemplary embodiment in accordance with the present invention.

Detailed Description of the Invention

The annealing apparatus 10 depicted in Fig. 1 is disposed with a transport track 12 along which an aluminum-comprising billet 14 can be moved. Said aluminum-comprising billet 14 is drawn through a die 18 arranged at the end of cold-processing means 16. Said aluminum-comprising billet 14 is then moved through an area provided with protective gas 20. A part of this area in which said aluminum-comprising billet 14 is moved through said protective gas 20 is an annealing path 22.

Said annealing path 22 is bordered by a first contact plate 24 and a second contact plate 26. Said first contact plate 24, which is in particular a negative pole, is preferably a draw plate able to exert a force on said aluminum-comprising billet 14 so as to move it.

Said first contact plate 24 as well as said second contact plate 26 are both connected to a voltage source and comprise aluminum so that the billet positioned respectively at said annealing path 22 is heated. The billet is guided by various deflection rollers 28.

Sub A13

Subsequent to annealing path 22, said aluminum-comprising billet 14 is moved along a second annealing path 30 which is bordered by said second contact plate 26 and a third contact plate 32.

Contact plates 32, 24 have the identical potential, which differs from the potential of contact plate 26.

Sub A14

Said aluminum-comprising billet 14 – already partly through annealing path 30 in the present given depiction – is cooled by a thin oil 34 prior to said oil being removed from said aluminum-comprising billet 14 by a stripping means, depicted here as die 36.

Annealing apparatus 10 is further disposed with a second draw plate which applies such a force on said aluminum-comprising billet 14 so as to move it.